Symmetric forward-backward correlations as seen at RHIC

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STAR Coll., PRL 103, 172301 (2009)
T. Lappi, L. McLerran, Nucl. Phys. A832, 330 (2010)
AB, arXiv:1108.0882 [hep-ph]

Outline

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  - measurement
  - comparison with models
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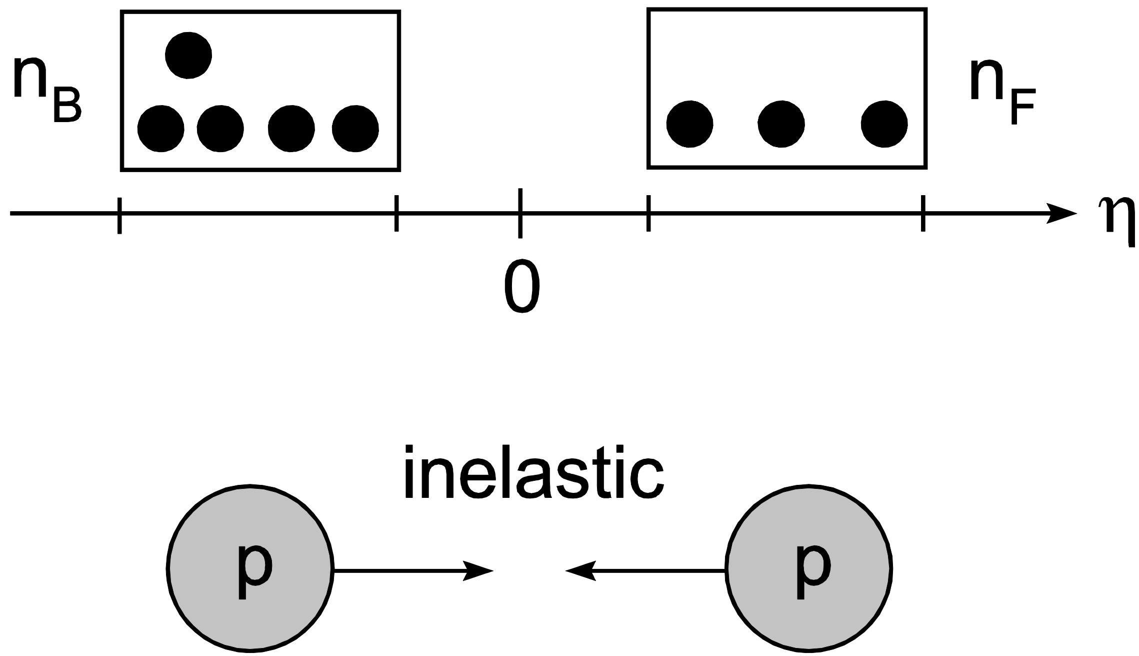
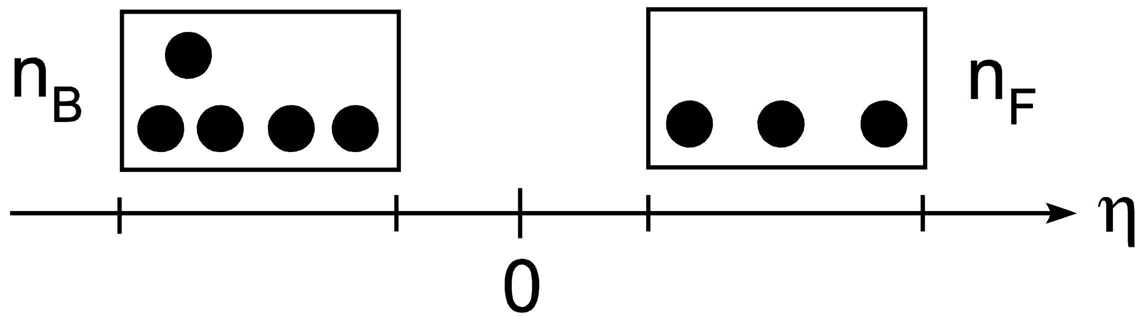
Introduction

Inelastic proton-proton collision



B = backward, F = forward, η = (pseudo)rapidity

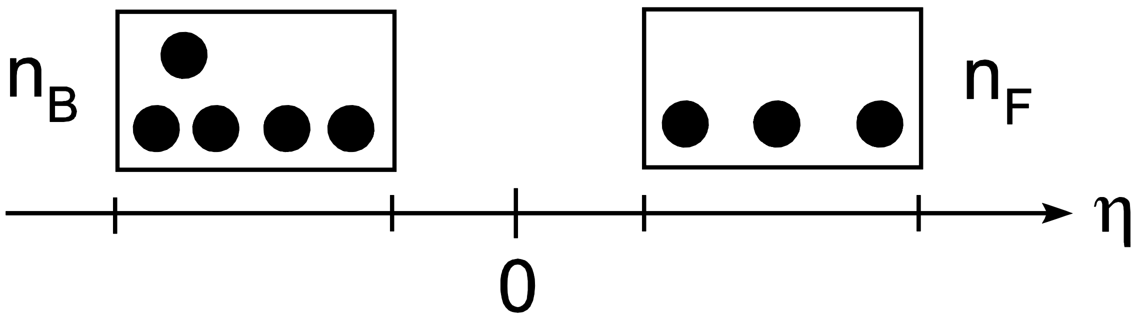
Forward-backward multiplicity correlations



$$correlation\text{:}\ \langle n_B n_F \rangle - \langle n_B \rangle \langle n_F \rangle$$

B = backward, F = forward, η = (pseudo)rapidity

Correlation coefficient



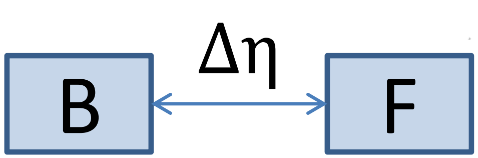
$$b = \frac{\langle n_B n_F \rangle - \langle n_B \rangle^2}{\langle n_B^2 \rangle - \langle n_B \rangle^2}$$

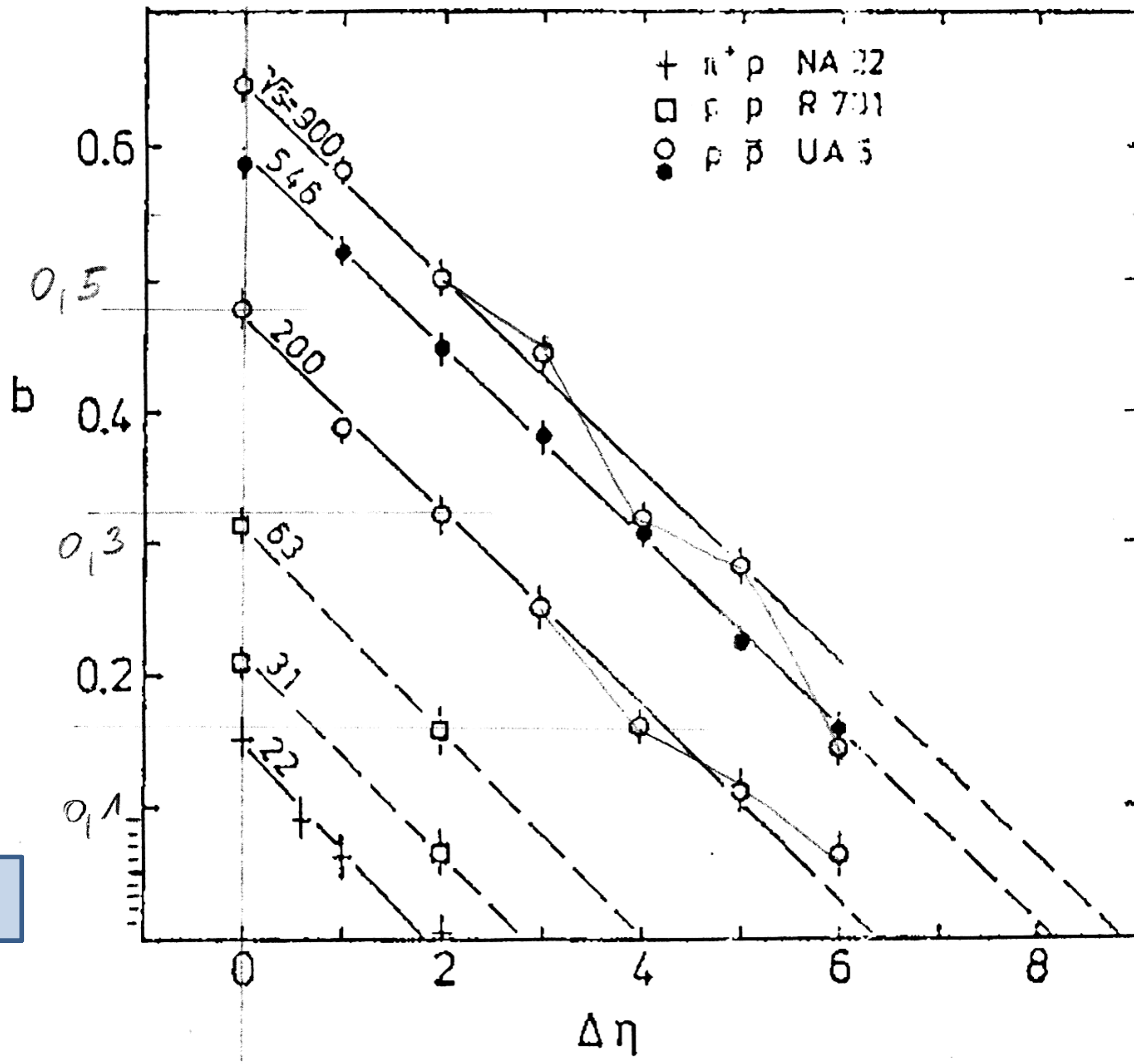
b = 1, maximum correlation

b = 0, no correlation

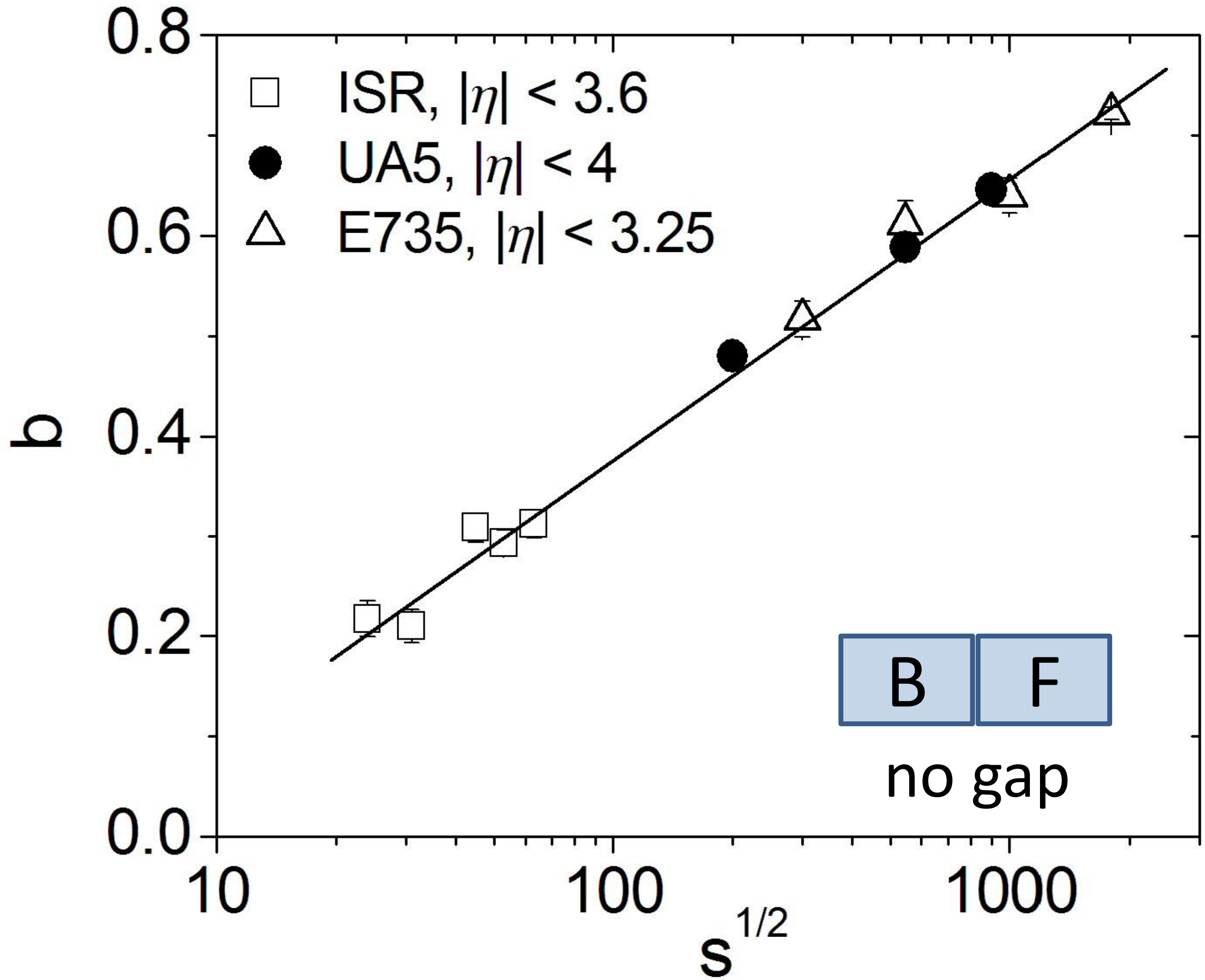
b = -1, maximum anticorrelation

correlation coefficient b for various energies and rapidity separations Δη between bins B and F



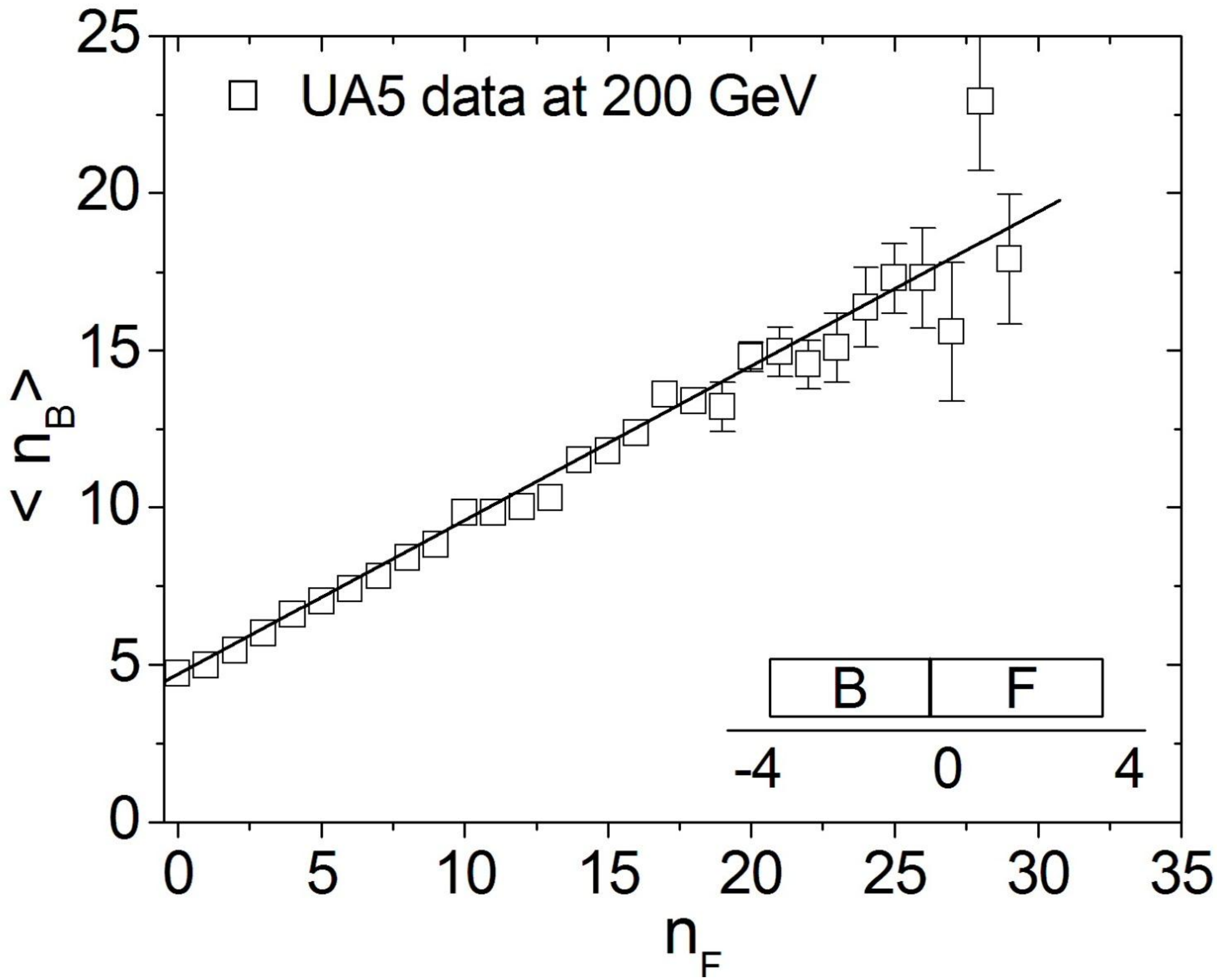


Energy dependence of b in pp



Average $\langle n_B \rangle$ in B at a given n_F in F

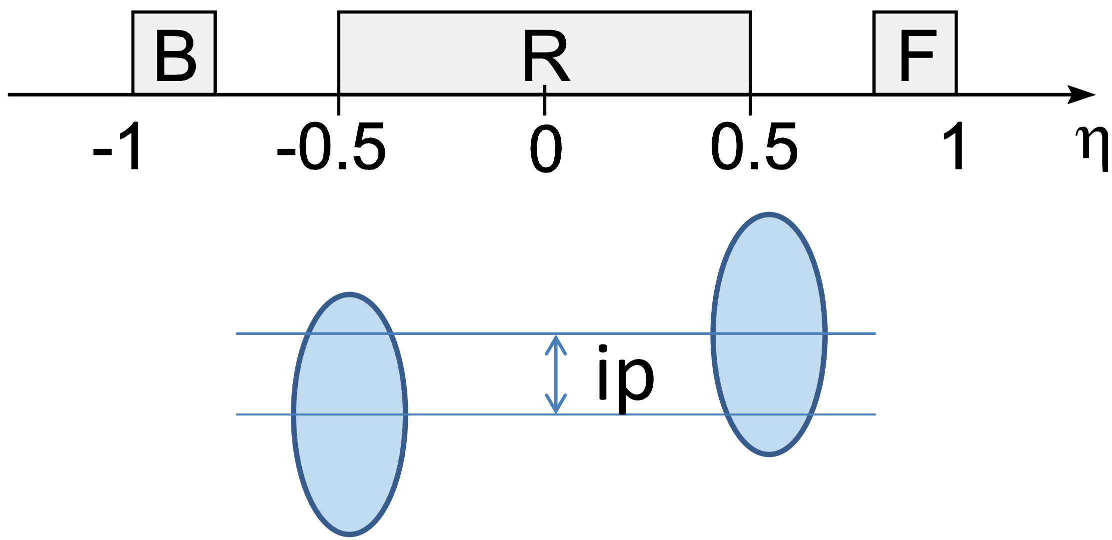
$\langle n_B \rangle = a + b n_F$ [the same b as before]



STAR data

STAR Coll., PRL 103, 172301 (2009)

AuAu collisions at 200 GeV. STAR configuration with maximum distance between B and F



ip = impact parameter (problem)

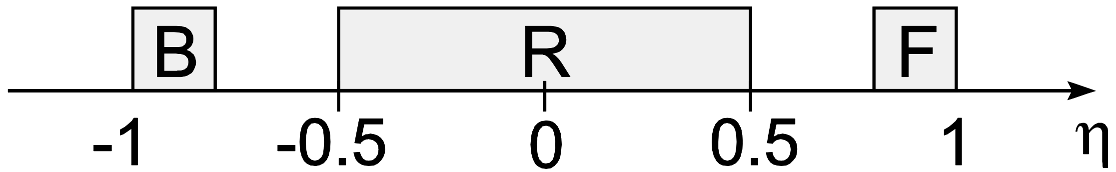
R = reference window (to determine centrality and more)

Why we want to measure b in AA collisions?

- it is recognized that correlations between particles with large separation in rapidity are born immediately after the collision

- we hope to see some fundamental difference between pp and AA

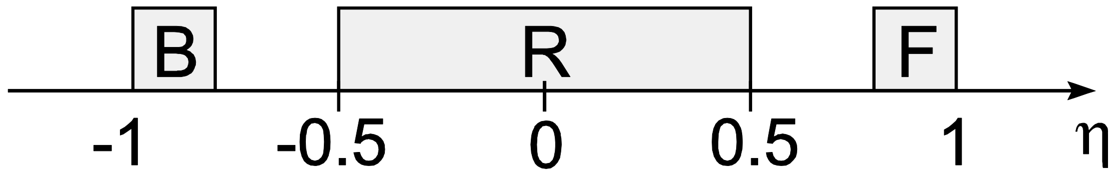
It is smart to reduce ip fluctuations



$$b_{BF}(n_R) = \frac{\langle n_B n_F \rangle_{n_R} - \langle n_B \rangle_{n_R}^2}{\langle n_B^2 \rangle_{n_R} - \langle n_B \rangle_{n_R}^2}$$

roughly speaking, STAR measures b at a given number of particles n_R in R …

… and more precisely

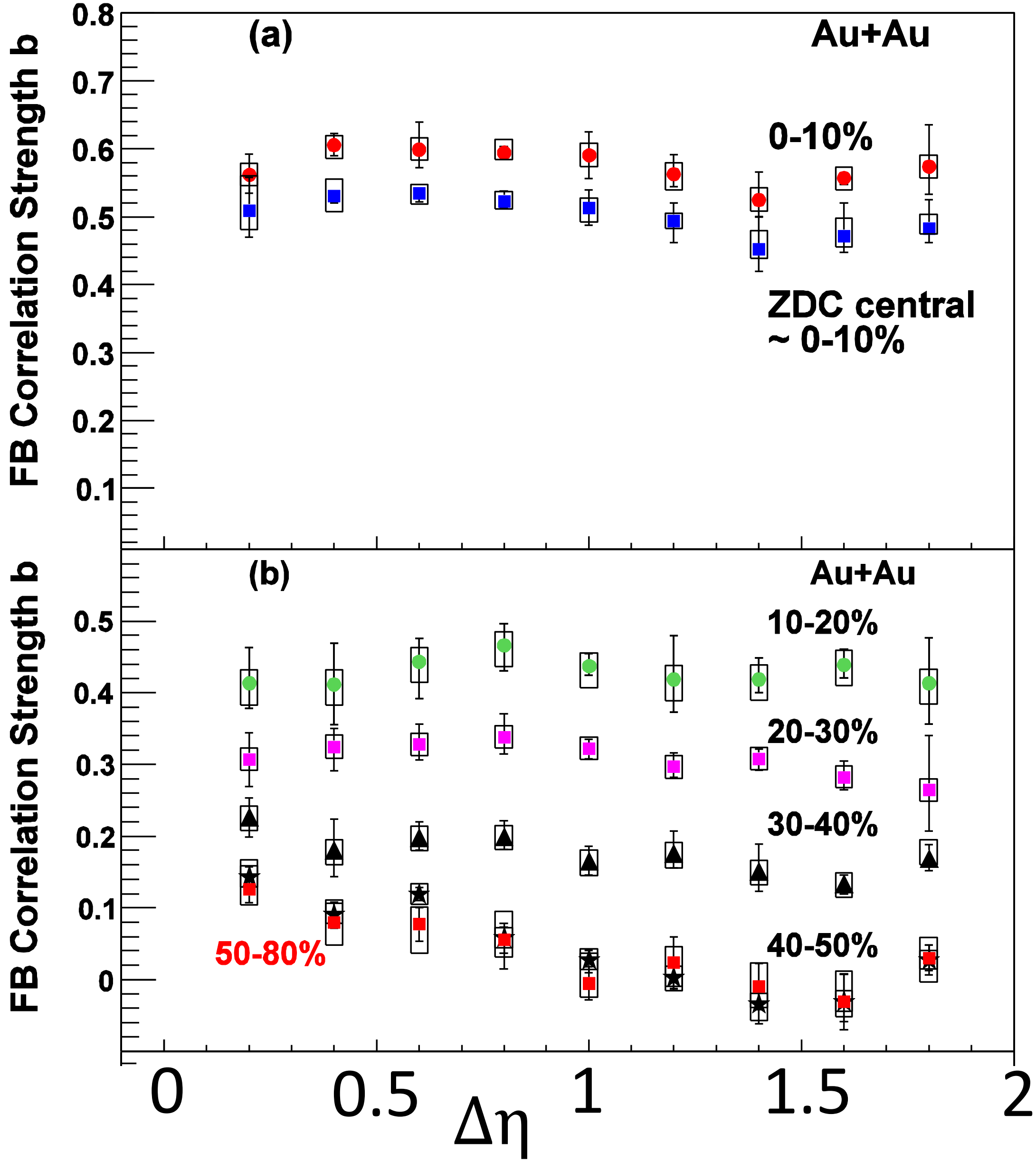


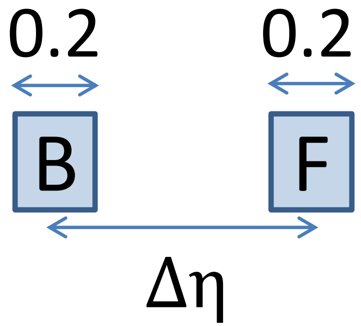
$$b_{BF}^{\star} = \frac{\sum_{n_R} P(n_R)\,[\langle n_B n_F\rangle_{n_R} - \langle n_B\rangle_{n_R}^2]}{\sum_{n_R} P(n_R)\,[\langle n_B^2\rangle_{n_R} - \langle n_B\rangle_{n_R}^2]}$$

where $P(n_R)$ is multiplicity distribution in R

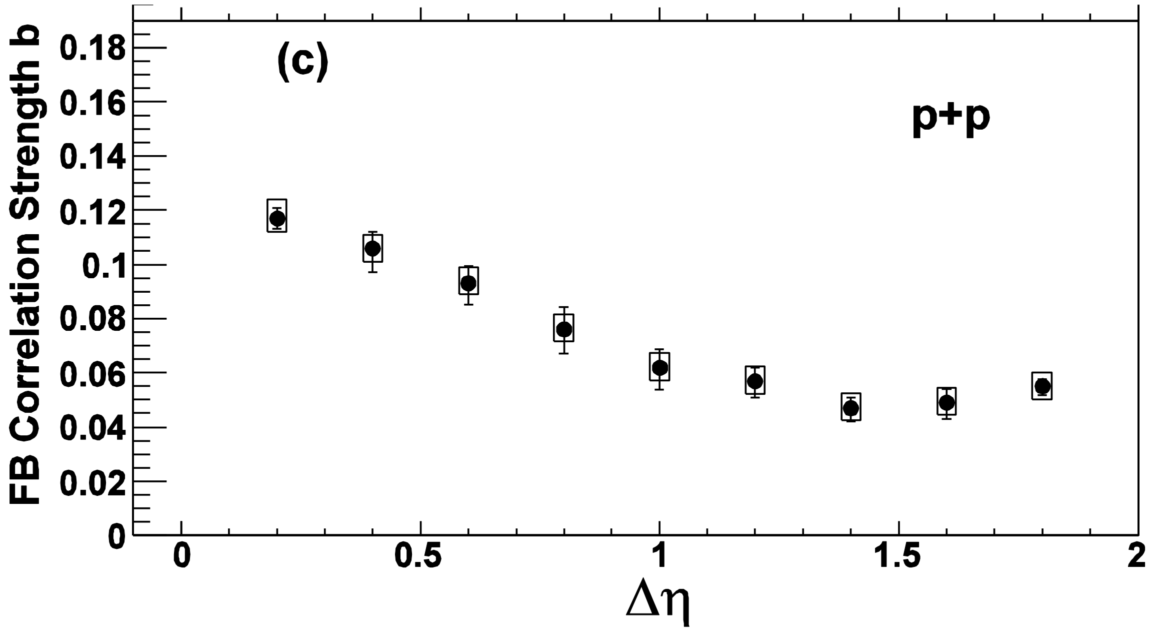
$\star$ = STAR method of measuring b

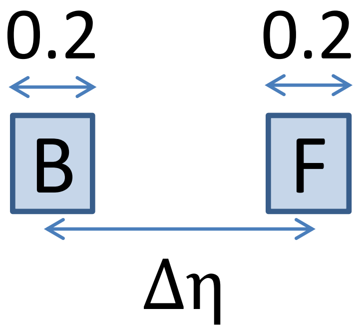
results for $b^{\star}_{BF}$, Au+Au, 200 GeV



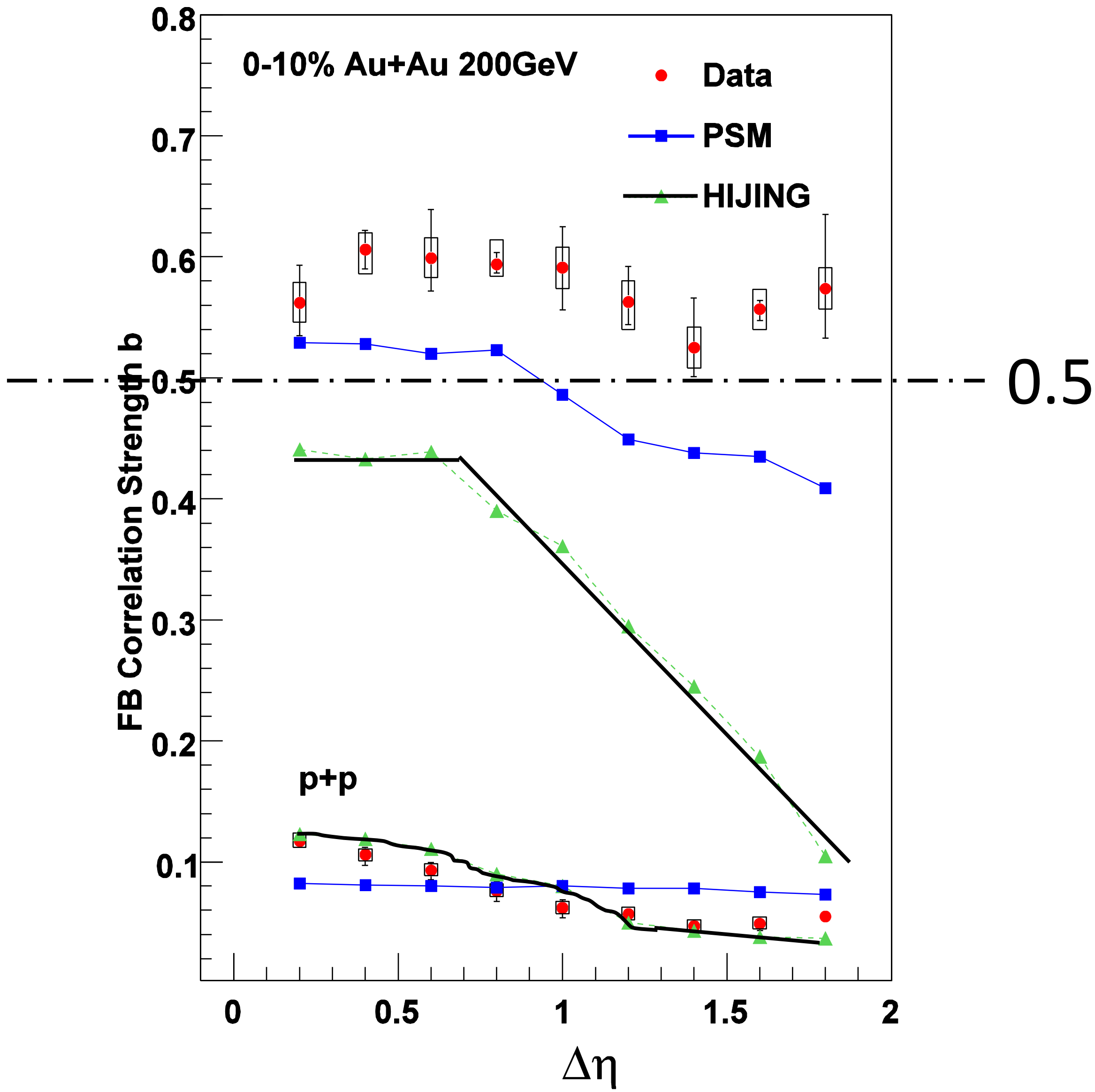


and results for $b^{\star}_{BF}$, p+p, 200 GeV





Comparison with models



Observations

- correlation coefficient increases with centrality
- it remains approximately constant across the measured region $|\eta| < 1$
- big difference between pp and AuAu
- fluctuations in impact parameter cannot explain the data*

* T. Lappi, L. McLerran, Nucl. Phys. A832 (2010) 330

Puzzle and symmetric correlation

T. Lappi, L. McLerran, Nucl. Phys. A832 (2010) 330

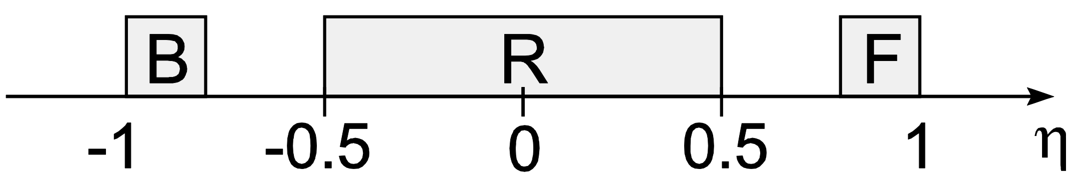
AB, arXiv:1108.0882 [hep-ph]

As noticed by T.Lappi and L.McLerran it is very strange that $b^{\star}_{BF} > \frac{1}{2}$ (we are interested in configuration with maximum Δη)

Assuming

$$\langle n_B \rangle_{n_R} = c_0 + c_1 n_R$$

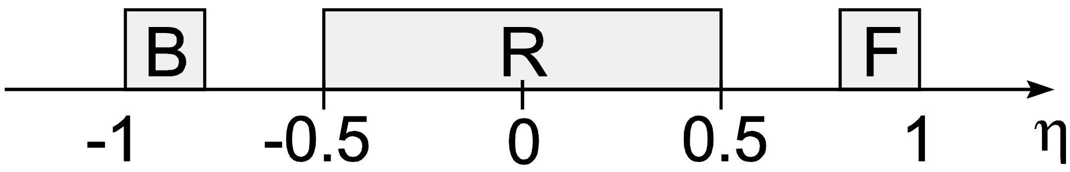
we can derive a general relation between $b^{\star}_{BF}$ and b_{BF} and b_{BR} (measured without fixing n_R)



The relation is

$$\boxed{b^{\star}_{BF} = \frac{b_{BF} - b^2_{BR}}{1 - b^2_{BR}}}$$

where b_{BF} and b_{BR} are measured without fixing n_R in R

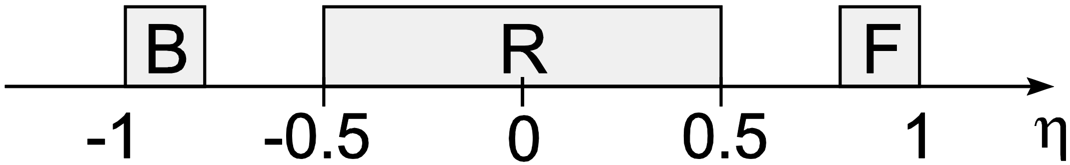


Assuming that two-particle correlation function depends only on $|\eta_1 - \eta_2|$ and is not increasing as a function of $|\eta_1 - \eta_2|$ we obtain

$$b_{BR} > b_{BF}$$

and

$$b_{BF}^{\star} = \frac{b_{BF} - b_{BR}^2}{1 - b_{BR}^2} < \frac{b_{BR} - b_{BR}^2}{1 - b_{BR}^2} = \frac{b_{BR}}{1 + b_{BR}} < \frac{1}{2}$$

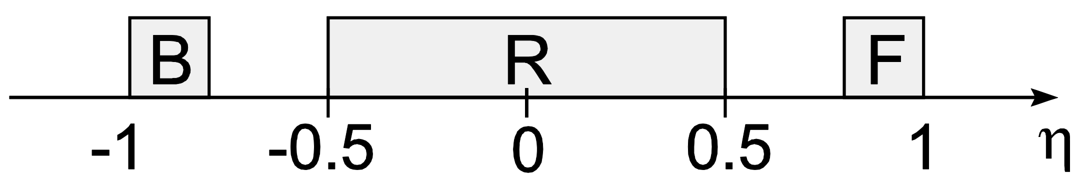


To obtain $b^{\star}_{BF} > \frac{1}{2}$ we have to assume that

$$b_{BR} < b_{BF}$$

STAR provided enough information to calculate b_{BF} and b_{BR} for the most central collisions

$$b_{BR} \approx 0.58, \qquad b_{BF} \approx 0.72$$



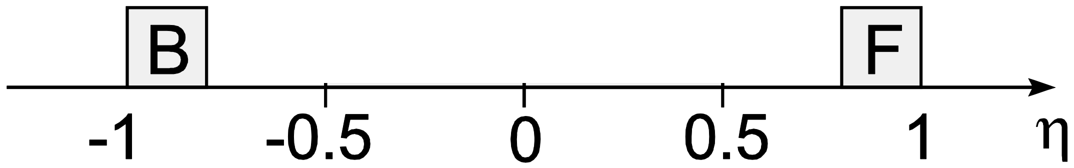
Options

Maybe in central AuAu collisions two-particle correlation function is increasing as a function of $|\eta_1 - \eta_2|$?

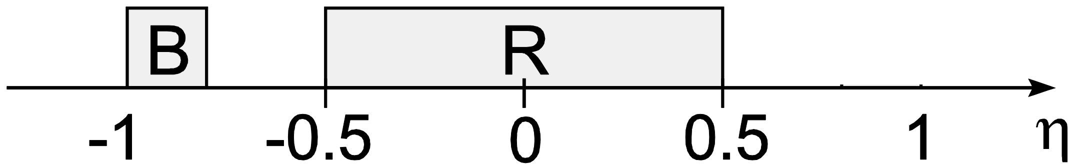
We know it is not the case!

It seems we have to assume that in central AuAu collisions 2-particle correlation function strongly decreases as a function of $|\eta_1 + \eta_2|$

Indeed,…



$$|\eta_1 + \eta_2| \approx 0$$



$$|\eta_1 + \eta_2| \approx 1$$

… if this is the case we can have

$$b_{BR} < b_{BF}$$

Conclusions

- We argued that in the most central AuAu collisions the 2-particle correlation function strongly decreases as a function of $|\eta_1 + \eta_2|$

- We probably see a source of *symmetric* correlations which strongly correlates bins located symmetrically around $\eta = 0$ and is less effective for asymmetric bins

- In *pp* collisions no “strange” physics is observed